Budapest 3D underground map

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Abstract

How can we represent the objects under the surface, if we want to show their real position and depth? How can we introduce overlapping objects like crossing metro lines, multi-storey cellars? My research theme is to develop a 3D presentation method for the underground objects, presenting it on the example of Budapest.

Keywords: underground, 3D, stereoscopic projection, Budapest

1. Introduction

Budapest is a beautiful city, millions of tourists visit every year. There are lots of buildings and parks on the surface, the city is many-sided, but there is another world underground, which is equally varies. You can find metro lines, cellars, caves, public works and many other objects.

My map presents natural and built objects in 3D. It can be displayed in the Visualization Center, a stereoscopic 3D laboratory of Eötvös Loránd University or by any equipments (e.g. 3D laptops) that offers real 3D projection.

2. Sources of data

2.1. Displaying objects

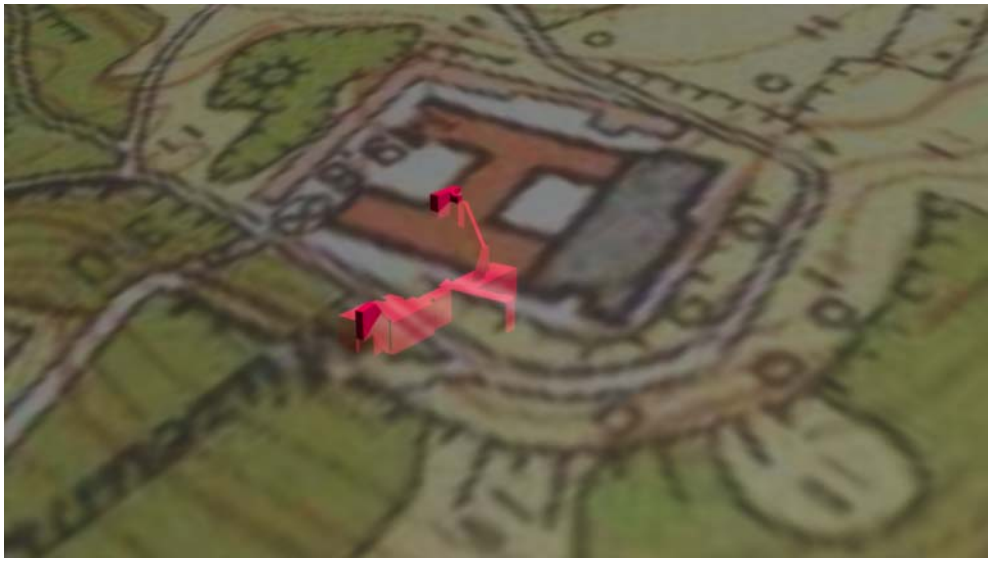
There are many different objects under the surface of Budapest we: four metro lines (line 4 is under construction), public works, limestone quarries in Kőbánya and in Budatétény, cellar systems, shelters, tunnels, garages, cellar prisons, cellar system and maze under the Buda Castle, wells, caves

and archaeological sites. The first task was to collect data and get aquire plans of these objects. As Budapest has no database about these facilities, so I had to collect the data from various sources, I also had to visit each place one-by-one. The plans of the first three metro lines are owned by the BKV[1], while the plans of the 4th line owned by the DBR Metro[2]. There is no even a united database of pipelines. In 2007 a combined public works database was initiated, but the work has just begun. (*Picture 1*)

Picture 1: The 3D model of Budapest textured with the topographic map

There are many shelters in Budapest, which are usually cellars of apartment houses, with their own water and electric services. The inhabitants of Budapest survived the Second World War in bunkers (*Picture 2*). The 2nd and 3rd metro lines were also shelters (Ungváry 2005). I could find many plans in VÁTI[3].

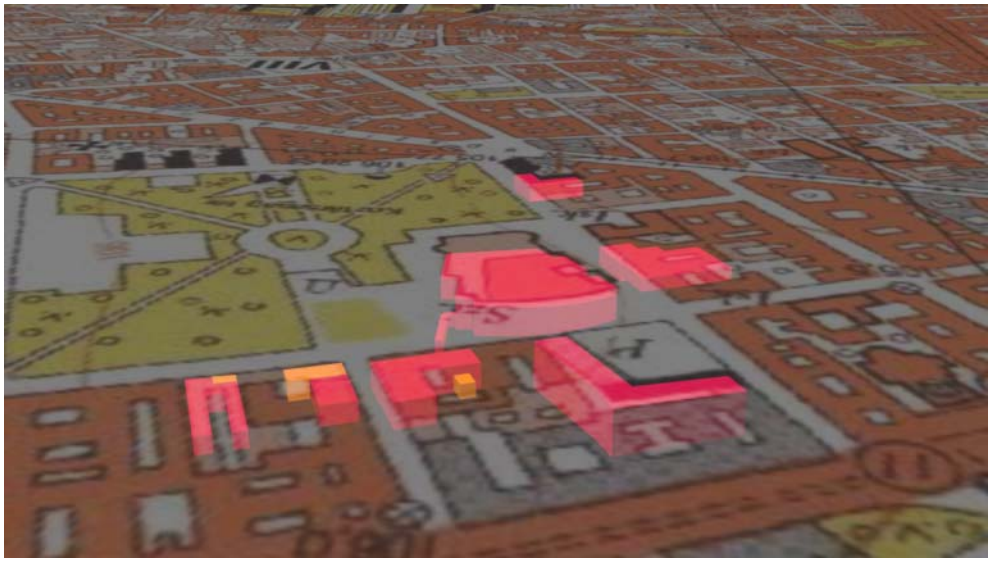
[1] BKV is the Budapest Transpot Company
[2] DBR Metro is a Metro Construction Company, they arebuilding the line 4.
[3] VÁTI is an archive were plans are stored



Picutre 2: The Cellar of Museum Kiscelli. It was originally a monastery in the 18th century, during Second World War operated as a shelter. Now it is functioning as a museum.

Cellar prisons operated in Budapest after Second World War during the Soviet regime. People, who resisted the system, were put in cellars or cellar prisons and were tortured (*Picture 3*). We have no idea how many people got hurt in these prisons during the dictatorship, because everything was done in secret. There are many tunnels in the downtown, which were connected to the main buildings of Soviet institutions and the cellar prisons. Sometimes they are more than 300 meters long. The Soviet soldiers used these tunnels to spirit hundreds of people away. To look after these objects is a difficult task. The Soviets tried to clear the evidences: they built walls to separate the tunnels, or water was let into the tunnels, but the signs can be seen and the tunnels and cellars exist today. There are witnesses[4] who can describe the objects, but to finding a plan of a tunnel is almost impossible. Some of the cellars can be found in VÁTI.

[4] Zoltán Dézsy made a dokumentum film about the cellar jails and the tunnels. His dokumentum film has 2 parts, broadcasted in National Hungarian Television in 1994, the tiltes: Pincebörtön I. and Pincebörtön II. www.dezsyzoltan.hu



Picture 3: Cellars (magenta) and shelters (orange) under Köztársaság Square. The square was a central place during the Soviet regime. Terrible urban legends related to Köztársaság Square from this period.

Under the Buda Castle, there is a multi-storey cellar system which was used already in the 15. century. Each house has its own cellar, these are 3 to 5 meter deep. Under a storey there are other ones. These cellars were connected, but later some of these parts parts were separated, now it looks like a maze. During Second World War a hospital was operating here. We can find museums there today. Maps and plans of the cellars can be found in the 1st District Council. There are two big stone-quarries under the surface in Budapest. Both of them are limestone quarries, but different of type and they are on opposit sides of Danube. The limestone-quarry of Kőbánya is on the east side. After the mining stopped here, it is being used as a storage (N. Kósa, Szablyár 2007). A large storage area belongs to the Dreher Breweries. Wine, conserve are being stocked and mushrooms are being raised in other parts of the quarry (*Picture 4, 5*). I could get plans from the architect of the company. On the west side of the Danube, there is the Budatétény cellar system., which area is a hilly counterpart to Kőbánya. Limestone was also mined here, but the cellars are different. The direction of cellars goes from the hill-side to inward, so the cellars are multi-storey. Here were cave dellings in the 19th and 20th centuries. Large area belongs to the Törley Champagne Company, which stocks the bottles in a 3 storey cellar system. There are fifty major natural caves in the Buda Hills. Other plans can be

found in VÁTI, district councils, construction companies and museums. Budapest is famous for thermal water, many baths can be found in the city.

2.2. Resources

The most difficult part was to know about the existence of an object. Large-scale of facilities were classified during the communist regime, many object s are classified today or have national defence function, only few people kno w about them. The public services, for example, the water
works have national defence function as well. I had to find these experts, wh o feared their data, and gave information only in confidence, so the sources of some data are only oral communication. The collection of data could be a n independent research project, because the sources are so much diverse. I needed plans to create the 3D model of an object. A 3D object can be made f rom the surface
drawings and sections. We know from them the figure, the height and the d epth of the underground object.
The basis of my map is a 3D relief about Budapest, textured with a topo-graphic map at 1:10000 scale. This scale does not allow the engineer to make plans, but this is not my goal. My map is an overview 3D model, which shows the type of objects, their figure and position under the surface. Using a larger scale would not be a cartographic rather engineer modelling.

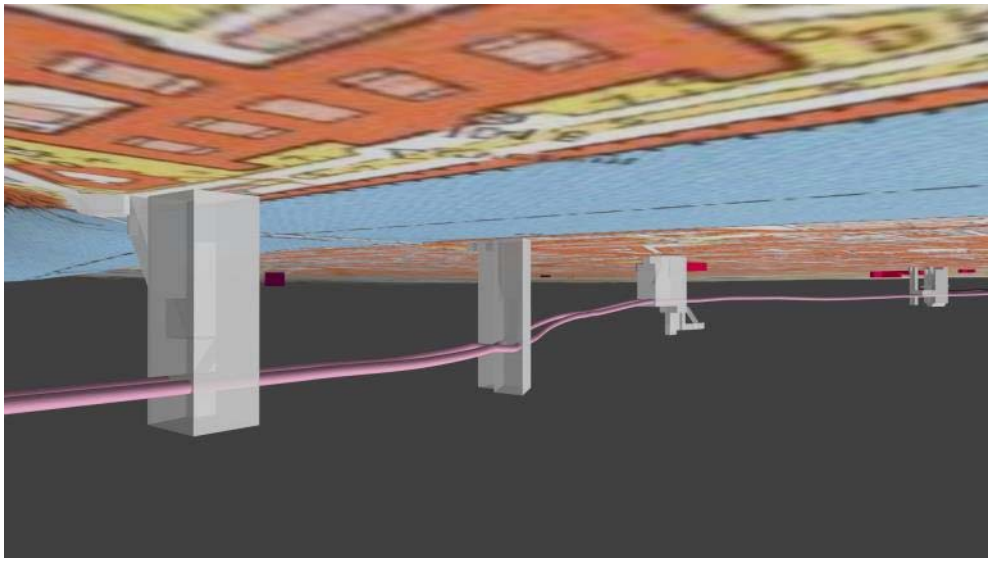
3. The 3D underground map

There are many objects under big cities and metropolises, this is why it is complicated to present them with traditional cartographic methods. The previous chapter said, that not only metro lines or public works can be found underground. In some cities 8 to 12 metro lines can be found, so their visualization faces difficulties, because it is impossible to show the depth of objects and their relationship. Traditional cartographic methods can show the track or the figure of the objects, but not the depth. The best way is to display the underground is in 3D. It is not a usual cartographic method, but the map can be impart for more information (Zsoldi 2011). We can see the objects clearly in 3D, but traditionally it is quite impossible to represent in 2D how three metro lines cross at Deák Square, the multi-storey cellar sys-tem under the Buda Castle, the cave systems in the Buda Hills or the multi-storey mine in Budatétény. The quarry in Kőbánya has only one storey, but each line path has different floor level and a different height (*Picture 4, 5*).

Picture 4: Part of the Kőbánya quarry, top view. The quarry had big importance in the 19th century, many famous buildings were built of these stones. It is functioning as beer, wine and conserve storage, mushrooms are being raised here now.

Picture 5: Part of the Kőbánya quarry, side view. The point of view is under the surface. The depth of floors and the height of lines are different.

There are cases when we can show more elevation data in a traditional 2D map, by using contour for relief, we can represent the stock of houses by colour and draw the power lines above the surface. We can read information and imagine the real world from such maps, because we have previous knowledge, we have seen buildings, hills, electric lines. This knowledge is different in the case of underground objects. We have been in a metro car or in a cellar, but we never had seen them from outside. Orienteering works in a different way if we are sitting in a metro car. We can feel, if the tram turns, but we do not realize the real position of the metro line or its contact with other lines (*Picture 6*). A 3D map gives new knowledge of the underground objects. We can create a complex picture about an unknown area that we can never examine from outside.



Picture 6: Part of Metro line 4 (it is under construction). We can see the tunnels (rose) and the stations (white) with their internal structure.

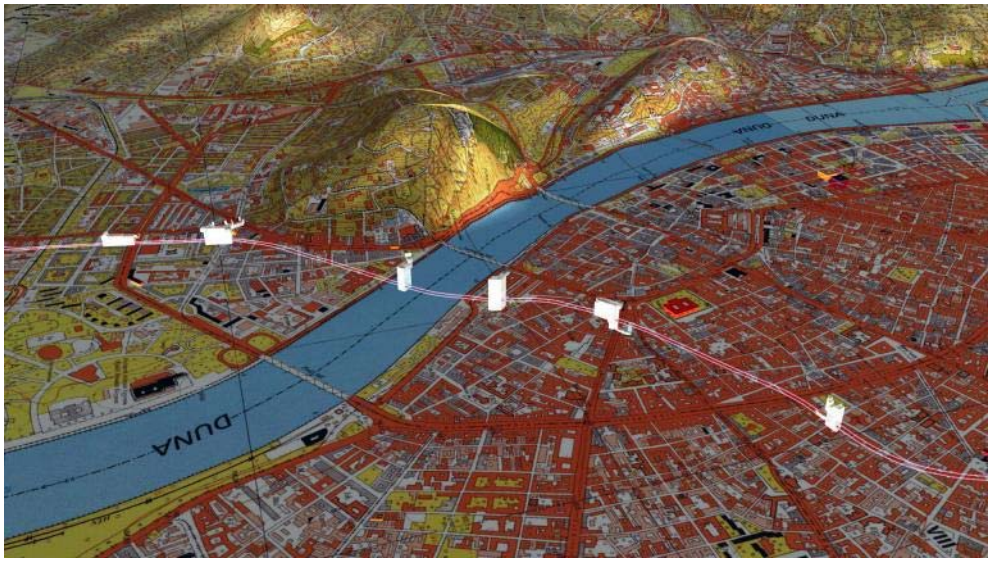
My research theme has two parts, the first is to collect data, and the second is to develop the 3D cartographic visualization method. I think that the we can consider the Budapest underground 3D map as a map, and not only a 3D model. It has scale and is generalized. My definition of scale differs from the one officially used in geology. The basic of my map is a 1:10000 scale to pographic map. I draw the underground objects from top view on it. As the topographic map scale is 1:10 000, I chose the 3D map scale identical. In the case of larger scale, we would not speak about cartographic scale, beca-

use it belongs to engineering planning or modelling. The generalization is important in my 3D map, because I display the objects in 0.1 metre accuracy (I use the simplification rule). As the data came from different sources, it is possible that the objects meet or overlap (Zentai 2000). I use the traditional shifting rule in this case. I do not display every cellar in Budapest, because almost each house has a cellar. In my 3D map I visualize only the special ones. The data came from different sources, but their formats are also different. In most cases there are no digital files, the plans are in paper format or a scanned pdf document. For instance the three metro line segments are in paper format. In this case I scanned the segments, and georeferenced the plans according to the topographic map. Then I created the 3D model. In some cases digital files are available in cad formats, but projection problems occured.

3.1. Real 3D display

The display of the Budapest underground 3D map is interactive. We can „walk" under the surface, and the model can be rotated and zoomed. It can be seen on computer on normal monitors, but the 3D model projected to 2D in this case. The best way is to view the model in real 3D display method. At Eötvös Loránd University there has a Visualization Centre. It is a stereoscopic 3D lab. The condition of the spatial vision is to see an object from the left and right eyes perspectives. These two sights have to be separated, the left eye can see only the left side view, the right eye only the right side picture. The Visualization Centre is a 10 square metre screen, with two projectors behind. Because the screen is too wide, two projectors are needed. The projectors work twice as fast (120 Hz) than the normal ones. They project the left and right sight sequentially very fast. To view objects in three dimensions, active shutter glasses are needed. These glasses darken once the right lens, then the left one. It happens very fast, because it is synchronized with the projector. When the projectors projected the left eye picture, the glass darkens the right lens, and we can see only by our left eye. After a fast changing the projector projects the right eye picture, the glass darkens the left lens, and we can see only by our right eye, and so on. The Budapest underground map can be displayed here with a Proto Engine application, which is a development by the Visualization Centre. The map can be displayed here in real 3D, it looks as if we were walking under the surface. Not only in the Visualization Centre can we see the Budapest underground 3D map, but on any device that allows real 3D, such as 3D TVs, laptops or mobiles.

The Budapest underground 3D map is a special map because we can look around under the surface in real 3D, and we can see how many and varied objects are there, their positions and depth and how they are related to each other. Modelling the underground objects of Budapest in 3D needs many years work. This research was started in September 2011, and it goes on since then. The purchase of the plans and maps, and the 3D modelling is a running project (*Picture 7*).



Picture 7: The picture shows the city center and Buda Hills. The 3D Budapest underground map project started in September 2011, and it is a running research. This picture shows the actual status at the end of 2012.

4. Conclusion

The worlds below the surface of big cities are so varied and many-sided. The objects are overlap each other, and have different depth, to visualize them in a traditional 2D map has difficulties. My research developed a 3D visualization cartographic method of displaying 3D objects below the surface. I took great care to collect data about plans and maps of the underground objects. The underground objects of Budapest have never been collected so widely yet. The 3D map can be displayed in real 3D with the right equipment. My Budapest underground 3D map can be used in state and governmental institutions. My method of visualizing underground objects in 3D can be used by companies or instituti-ons for public works, public trans-

port, tourism, shelter databases, national defence, multi-storey garage data base, investigations of the underflow of cellars. The natural spings and the built objects can be seen to-gether in a map, we can analyze the effect on each other.

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